

## WHP Cruise Summary Information

WOCE section designation	A01W, AR05, AR13
Expedition designation (EXPOCODE)	18HU95011_1
Chief Scientist(s) and their affiliation	John Lazier, BIO
Dates	1995.06.07 – 1995.07.05
Ship	HUDSON
Ports of call	Nova Scotia, Canada to Newfoundland, Canada
Number of stations	88
Geographic boundaries of the stations	60°30.93"N 59°25.40"W 30°58.70"W 41°46.02"N
Floats and drifters deployed	6 Floats
Moorings deployed or recovered	see below
Contributing Authors	A. Isenor
(In order of appearance)	M. Scotney

## WHP Cruise and Data Information

Instructions: Click on items below to locate primary reference(s) or use navigation tools above.

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CRUISE REPORT  
HUDSON 95011  
LABRADOR SEA  
WOCE LINE A1W  
7 JUNE - 5 JULY, 1995

## **A. CRUISE NARRATIVE**

### **1. Highlights**

- a. WOCE Designation:** Woce Line A1W
- b. Expedition Designation:** Hudson 95011
- c. Chief Scientist:** John R. N. Lazier  
Ocean Circulation Division  
Physical and Chemical Sciences Branch  
Department of Fisheries and Oceans  
Bedford Institute of Oceanography  
P.O. Box 1006  
Dartmouth, NS, Canada B2Y 2A4  
  
FAX: 902 426 7827  
Internet: j\_lazier@bionet.bio.dfo.ca
- d. Ship:** CSS Hudson
- e. Ports of Call:** June 8 BIO, Dartmouth, NS, Canada  
July 4 St. John's, Newfoundland, Canada
- f. Cruise Dates:** June 7, 1995 to July 5, 1995

### **2. Cruise Summary Information**

#### **a. Cruise Track**

A cruise track is shown in Figure 1. Ship position at midnight on each day of the cruise is indicated with an asterisk.

The station positions are shown in Figures 2 and 3. Figure 2 shows the stations occupied along A1W while Figure 3 shows stations along the southerly line from Greenland that approximately follows AR5. Some station numbers are indicated for clarity. The various types of stations are also indicated.

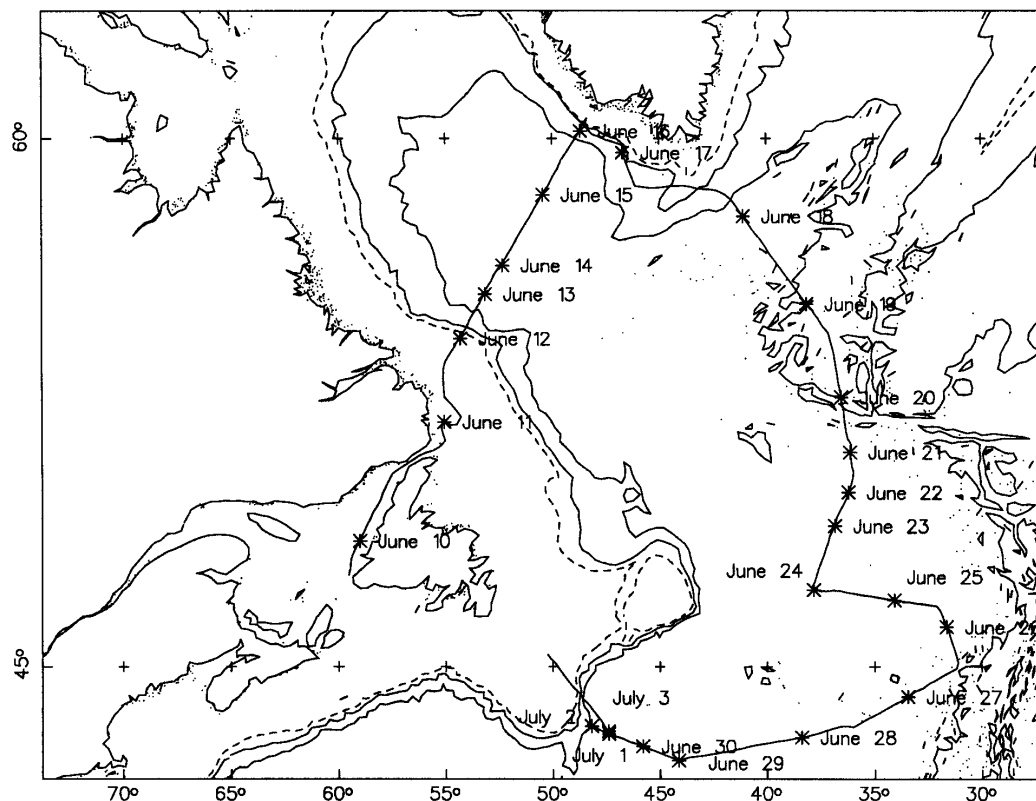


Fig. 1 Cruise track for 95011. Asterisks indicate a time of 0000 Z on the day indicated.

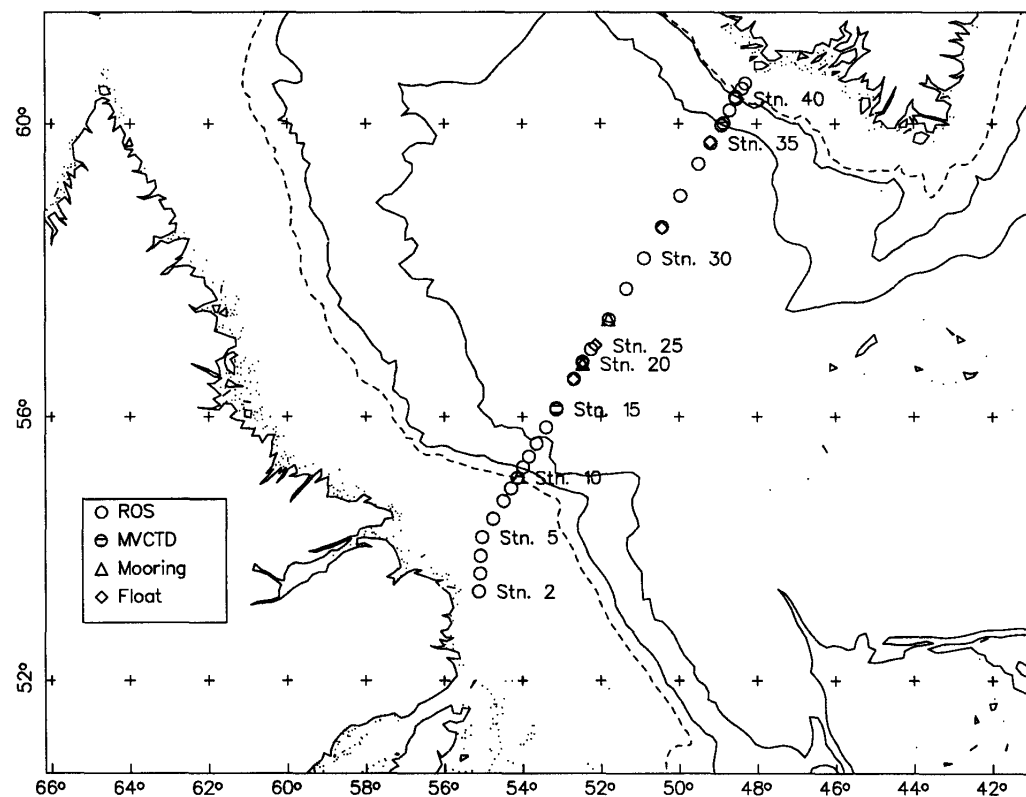


Fig. 2 The type and location of stations along A1W line.

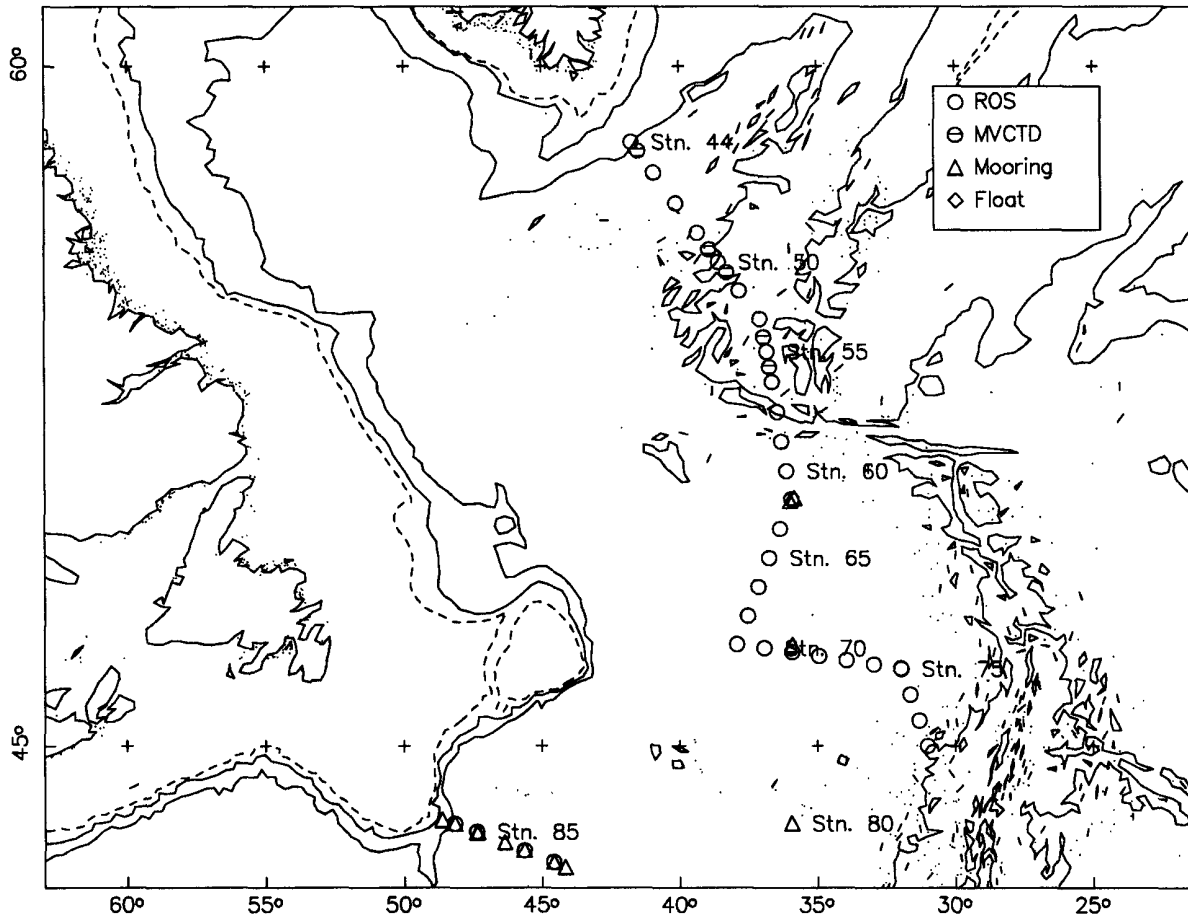


Fig. 3 The type and location of stations along the AR5 line.

#### b. Total Number of Stations Occupied

61 full depth WHP small volume CTD stations with up to 23 rosette bottles. Depending on the station, water samples were analyzed for CFC's, carbon tetrachloride, methyl chloroform, total carbonate, alkalinity, oxygen, salinity, nutrients, tritium, helium, and oxygen isotopes.

3 CTD casts with no water samples

8 MVCTD casts, with an additional cast with MVCTD attached to CTD rosette frame

59 Full depth velocity profiles using a lowered ADCP attached to the CTD/rosette

6 Float deployments

4 IES Mooring Recoveries (2 unsuccessful attempts)

4 Sound source mooring recoveries

1 IES mooring deployed

2 Current meter moorings deployed

3 Current meter moorings recovered (2 through dragging)

### **c. Floats and Drifters Deployed**

A total of six floats were launched during the cruise, all on the A1W line. Of the six, three were ALACE (Autonomous Lagrangian Circulation Explorer) floats launched for Ray Schmitt of WHOI (1 float) and Russ Davis of SIO (2 floats). The remaining three were deep lagrangian floats launched for Eric d'Asaro of APL/UW.

### **d. Moorings Deployed or Recovered**

The multi-instrument mooring deployed during the BIO cruise to AR7W in 1994 (WOCE Expocode 18HU94008) was recovered and a duplicate mooring was deployed in the same location. The deployed mooring consisted of 6 Seacat temperature/conductivity recorders, 6 Aanderaa current meters, 1 acoustic doppler current profiler (ADCP), 1 WOTAN (weather observations through ambient noise) and 1 CTD with a device for measuring the total partial pressure of dissolved gas in the water.

A current meter mooring consisting of one current meter positioned 15 m off the bottom was deployed along the 1000 m isobath on the Labrador side of A1W. This mooring was deployed for Peter Rhines of the University of Washington.

A total of four RAFOS Sound Source moorings were recovered. These moorings were deployed by the R/V Oceanus in August 1993. The Sound Sources were used in a RAFOS float program lead by Tom Rossby of the University of Rhode Island. Over the past 2 years, floats have been set in and near the North Atlantic Current in order to map the lagrangian velocity fields on isopycnal surfaces in the upper pycnocline throughout the Newfoundland Basin. The Sound Sources are used to spatially locate the floats during the program.

Four of a total of six Inverted Echo Sounders (IES) were recovered from the area of the ACM6 mooring line. The Echo Sounders measure the travel time of an acoustic signal between the instrument and the surface. The data can be used to determine the vertical density field and dynamic height. This program is led by Randy Watts of the University of Rhode Island.

During the Clarke 95003 cruise (WOCE Expocode 18HU95003), two planned recoveries of moorings could not be completed due to release problems. During this cruise, Hudson dragged the area hoping to recover these 2 moorings. The operation was successful, as all current meters on mooring 1124 on the 3900 m isobath and 3 of the 4 current meters on mooring 1122 on the 2500 m isobath were recovered.

### 3. List of Principal Investigators

Name	Affiliation	Responsibility
John R. N. Lazier	BIO	CTD data, shipboard ADCP data, current meter data
		j_lazier@bionet.bio.dfo.ca
Peter Jones	BIO	chemical data
		p_jones@bionet.bio.dfo.ca
Robert Pickart	WHOI	lowered ADCP
		pickart@rsp.whoi.edu
Peter Rhines	UW	current meter data
		rhines@killer.ocean.washington.edu
Peter Schlosser	LDEO	tritium, helium data
		peters@ldeo.columbia.edu
Randy Watts	URI	IES, sound sources, current meter data
		randy@drw.gso.uri.edu

See Section 7 for addresses.

### 4. Scientific Programme and Methods

#### a. Narrative

One of the aims of the annual occupation of the WOCE AR7W (or A1W) line across the Labrador Sea is to monitor the water mass properties in the region especially the Labrador Sea Water (LSW) which is renewed by deep convection in winter to as much as 2300 m. The temperature and salinity of this water mass changes by varying amounts each winter depending on the severity of the winter and the temperature and salinity of the waters that are mixed up by the convection. Estimates of its average temperature and salinity for the years 1990-1995, except 1991, are shown in Figure 4.

Between 1990 and 1993 the temperature decreased by 0.1 C while the salinity increased by 0.009 resulting in an increase in density ( $=+1000 \text{ kg m}^{-3}$ ) of  $0.02 \text{ kg m}^{-3}$ . The temperature decrease is due to large heat losses to the atmosphere in the two abnormally severe winters. The increase in salinity results from the convection penetrating deeper than in previous years into layers of higher salinity. Some of the higher salinity water becomes incorporated in the convecting layer and raises its salinity.

Between 1993 and 1994 the estimates in Figure 4 show the average temperature and salinity decreased then increased between 1994 and 1995. Over both winters these changes were such that no significant change in resulted.

The temperature vs. salinity curves in Figure 5 and 6 give a more detailed view of the LSW properties in 1994 and 1995. In the core of the water mass, where  $34.682 < < 34.687 \text{ kg m}^{-3}$ , the temperature and salinity variation along surfaces is significantly greater in 1994. In 1995 the temperature and salinity gradients along surfaces over 7 of the 9 stations is less than half the range in 1994. This difference seems to be an effect of the

convection process and possibly an important clue to how convection works but as of now the connection is not understood.

The 2nd objective of the Labrador Sea part of the program was to replace the NOAA/ACCP funded mooring in the center of the central gyre. The purpose of the mooring is to obtain data throughout the year to better understand the formation of the LSW and the variability in its properties induced by inter-annual variations in the heat and salt fluxes. The mooring placed in May 1994 was recovered intact yielding 6 complete sea-cat records and almost 6 complete current meter records.

In the Labrador Sea we also successfully launched three "Deep Lagrangian Floats" for Eric d'Asaro of the Applied Physics Laboratory, University of Washington, Seattle; one ALACE float for Ray Schmitt of the Woods Hole Oceanographic Institution and two ALACE floats for Russ Davis of the Scripps Institution of Oceanography.

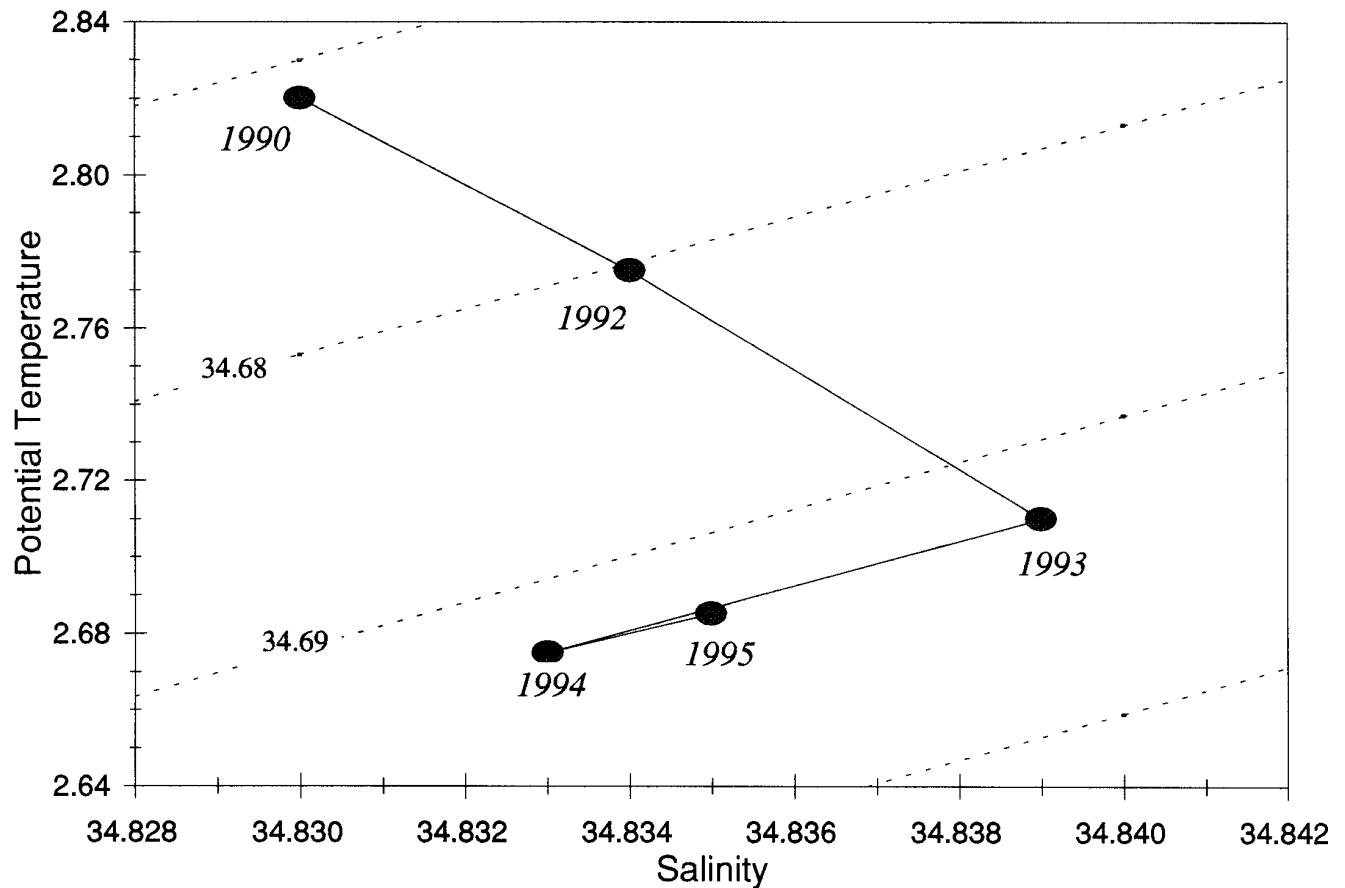


Fig. 4 The average temperature and salinity of the Labrador Sea Water in 1990, 1992, 1993, 1994 and 1995. The dotted curves are lines of constant 1.5 (= density referenced to 1500 db minus  $1000 \text{ kg m}^{-3}$ ).

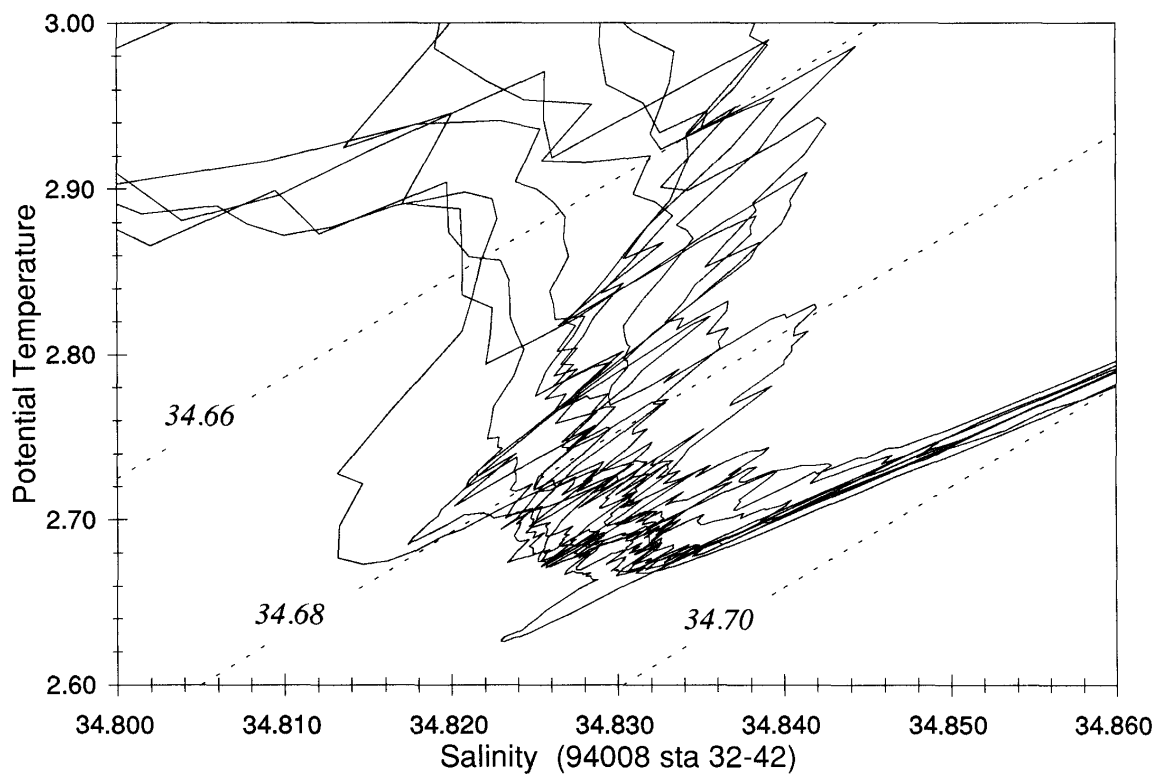


Fig. 5 Temperature vs. salinity curves for stations 32 to 42 (sites 13 to 21) obtained in May 1994. Dotted curves as in Figure 4.

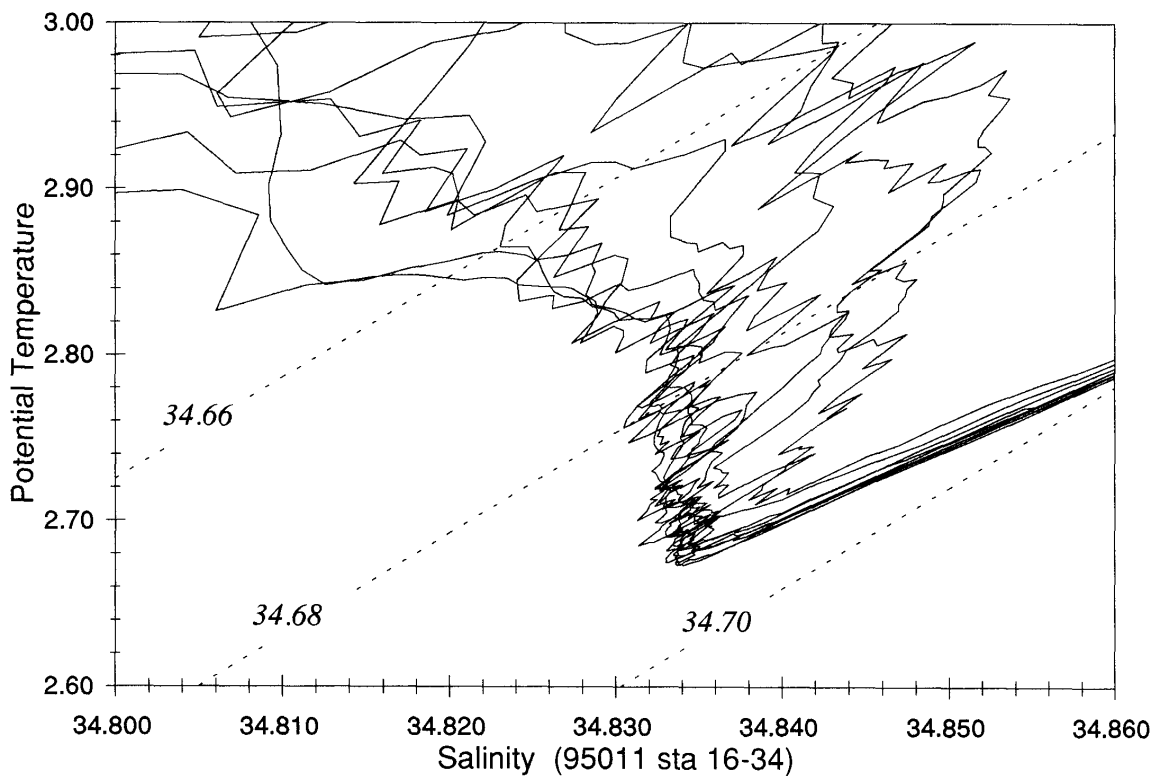


Fig. 6 Temperature vs. salinity curves for stations 16 to 34 (sites 13 to 21) obtained in June 1995. Dotted curves as in Figure 4.

On the original plan was the requirement to recover 4 sound source moorings for Tom Rossby of the University of Rhode Island and 6 inverted echo sounders for Randy Watts also of the University of Rhode Island. But following the failure to recover 2 moorings in the Newfoundland Basin on cruise 95003 the plan was altered to include dragging for these.

All the sound sources were recovered intact, however, only 4 of the IESs. The dragging was successful in recovering all the current meters on mooring 1124 on the 3900 m isobath and 3 of the 4 current meters on mooring 1122. Two attempts were made to get mooring 1124. The first on June 30 recovered 4 current meters and the second on July 2 recovered the rest of the mooring including two current meters and the release.

On the way between the sound source moorings and between Cape Farewell and the northern most sound source mooring we obtained CTD and chemistry data at roughly 40 mile spacings. The motivation for these stations was to observe the characteristics of the LSW across the entrance to the Irminger Sea and between 48° and 52°N west of the Mid Atlantic Ridge along roughly 37°W. The latter section crosses the path of the LSW that flows from the western into the eastern basin of the North Atlantic.

Figure 7 shows one comparison from these two sections constructed from the CTD data. Shown are estimates of the layer thickness between surfaces  $0.002 \text{ kg m}^{-3}$  apart. Since LSW is formed by convection the water mass is nearly homogeneous in the Labrador Sea. As it flows away from the Labrador Sea the thickness of the layer is an indicator of its presence. The higher thick curve in Figure 7 is from four of the stations southeast of Cape Farewell at the entrance to the Irminger Sea. The other thick curve is the average from the stations south of the Charlie Gibbs Fracture Zone representing the water flowing into the eastern basin. The layer thickness across the entrance to the Irminger Sea is about 4 times that of the other curve and is centered on a of 34.687. The peak in the other curve is centered at  $= 34.665 \text{ kg m}^{-3}$ . The peak at the higher value represents Labrador Sea Water formed in 1993, 94 or 95 as it closely matches the for those years shown in Figure 4 for the Labrador Sea. The lower peak for the water passing through to the eastern basin suggests a source which is of a lower density than any of the values plotted on Figure 4. In 1990, for example, the Labrador Sea Water was at  $34.672 \text{ kg m}^{-3}$  which is slightly higher than the peak in Figure 6. This suggests the water passing through to the eastern basin probably formed before 1990.

## **5. Major Problems and Goals Not Achieved**

Unfortunately, ice prevented 4 CTD stations on the Cape Farewell Shelf at the northern extension of the AR5 line. The first station on AR5 was therefore in about 3000 m of water.

Also, 2 inverted echo sounders were not recovered due to release problems.

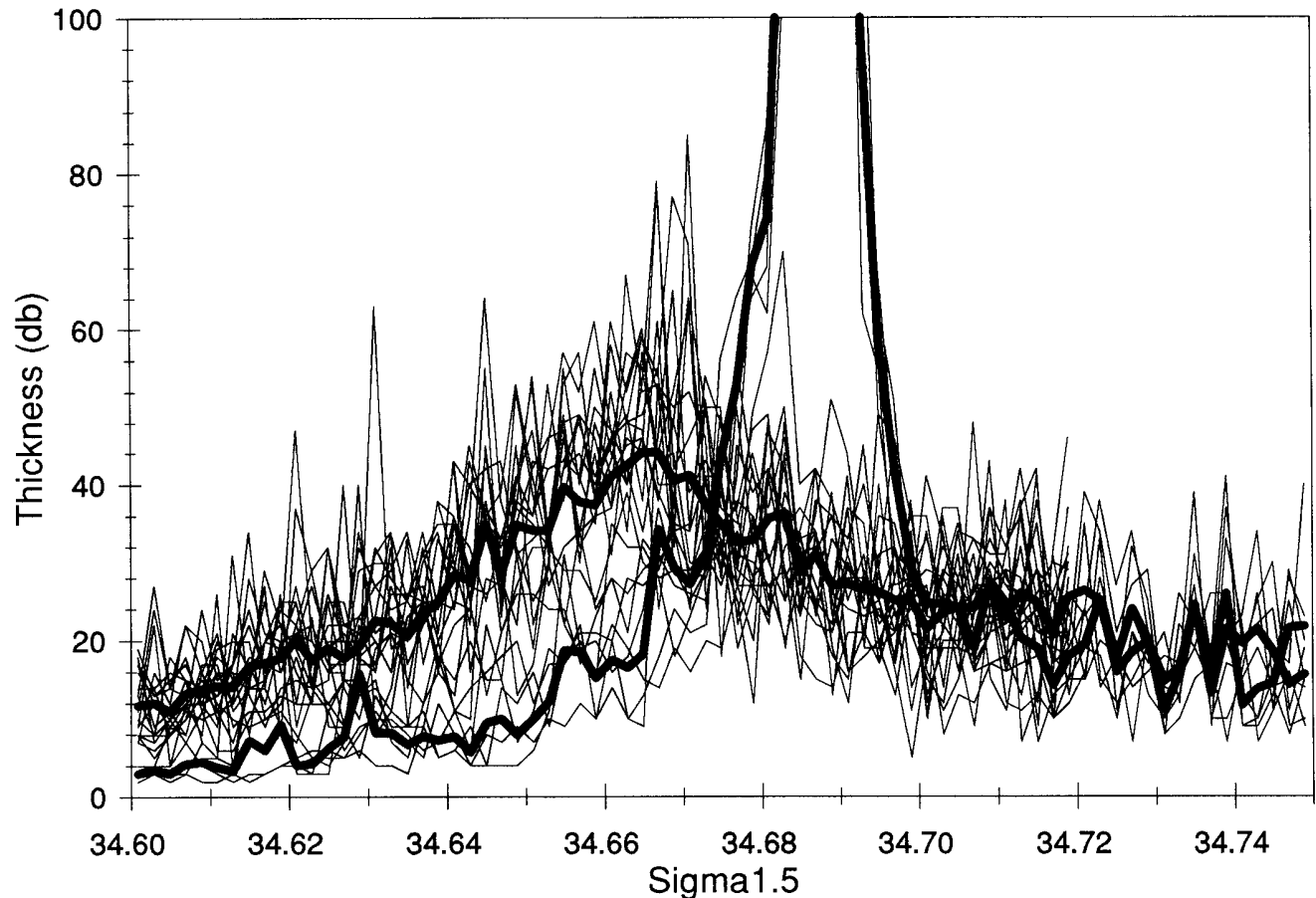


Fig. 7 Estimates of layer thickness in decibars (db) every  $0.002 \text{ kg m}^{-3}$  in 1.5 and their averages at two sets of stations. The higher peak centered at  $34.687 \text{ kg m}^{-3}$  is from stations 45 to 48 southeast of Cape Farewell. The peak at  $34.665$  is from stations 59 to 79.

## 6. Other Incidents of Note

The MVCTD is a profiling CTD system that can be deployed when a ship is steaming at 10 knots. The system has been tested on a previous cruise to the Newfoundland Basin (Clarke, WOCE Expocode 18HU94030) and further testing was conducted during this cruise. A total of eight casts were completed using the MVCTD and winch gear (1 cast was performed with the MVCTD attached to the CTD rosette frame) during this cruise. Sadly, however, at Station 56 the instrument was lost during recovery.

A rack containing three digital thermometers was lost on Station 41, cast 2. A set screw holds the rack to the SIO bottle, but allows the rack to rotate about the attachment to the bottle. Speculation is that the set screw became loose and when the bottle was fired, the rack fell off the bottle.

On Station 65 the CTD was brought back onboard with a kink in the winch/conducting wire. The kink was located about 5 m from the CTD. A splice and retermination was

carried out. The probable cause of the kink was a lowering of the CTD on the up-cast at about 3500 m that resulted in slack wire.

The heave compensation winch was also tested on this cruise. This system was designed to modulate the speed of the winch to compensate for the heaving motion of the ship. It was first tested on the Clarke 95003 (WOCE Expocode 18HU95003) cruise and found to make the motion of the CTD worse. The electronics were then adjusted to reduce to zero the component of acceleration fed to the control amplifier. The controller was tried on two stations during this cruise, with major reduction of the variations of the CTD speed. Unfortunately (!! ) the weather was always good and the heave motion was less than 1 m/s. We cannot say what the performance will be in rough seas.

## 7. List of Cruise Participants

Name	Responsibility	Affiliation
Larry Bellefontaine	Salinometer/Watch keeper	BIO
Brian Beanlands	MVCTD	BIO
Gerry Boudreau	Computers/Watch keeper	BIO
Pierre Clement	Nutrients/Oxygens	BIO
Jean-Guy Dessureault	MVCTD	BIO
Bob Gershey	CFC/Alkalinity/Carbonate	BDRResearch
Mike Hingston	CFC/Alkalinity/Carbonate	BDRResearch
Anthony Isenor	Data Quality/Watch keeper	BIO
Peter Jones	Assistant Scientist	BIO
John Lazier	Chief Scientist	BIO
Jonathon Lilly	Watch keeper	UW
Christopher Meinen	Sound Sources/IES/Watch keeper	URI
Mike Mulroney	Sound Sources/IES/Watch keeper	URI
Maureen Noonan	Helium/Tritium Sampling	LDEO
Patrick Roussel	Water keeper	Dal
Murray Scotney	Moorings/CTD/Watch keeper	BIO
Randy Watts	Sound Sources/IES	URI
Frank Zemlyak	CFC/Alkalinity/Carbonate	BIO

BIO Bedford Institute of Oceanography  
P.O. Box 1006  
Dartmouth, NS, CANADA B2Y2A4

BDR BDR Research Ltd.  
Box 652, Station 'M'  
Halifax, N.S.,  
Canada, B3J2T3

Dal Dalhousie University  
Halifax, Nova Scotia

LDEO Lamont-Doherty Earth Observatory of Columbia University  
Palisades, NY, 10964, USA

URI University of Rhode Island Narragansett Marine Lab  
South Ferry Road, Narragansett  
Rhode Island 02882, USA

UW University of Washington  
Seattle, WA, USA

WHOI Woods Hole Oceanographic Institution  
Woods Hole, MA 02543, USA

## **B. UNDERWAY MEASUREMENTS**

### **1. Navigation and Bathymetry** (Anthony W. Isenor)

The navigation system onboard CSS Hudson consists of a Trimble Navigation Loran-GPS 10X decoder and AGCNAV. The decoder receives the satellite fixes and decodes the signals to obtain latitude, longitude and time. The decoder signals are about 1 Hz. The navigation data were logged at one-minute intervals on a PC. This PC was running the AGCNAV software package, a PC based display, and way-point setting software package developed at the Atlantic Geoscience Centre at BIO. This software graphically displays ship position, way-points, course, speed, etc. to the various science working areas.

The echo sounder system used for collecting bathymetric data consisted of a Raytheon Line Scan Recorder, Model LSR 1811-1 (serial number A105) connected to a hull mounted 12kHz transducer. The transducer beam width is 15 degrees. The sweep rate of the record was adjusted throughout the course of data collection to aid in identifying the bottom signal. The recorder was also linked to a clock, and thus could indicate 5-minute intervals on the sounder paper. The system was used to collect bathymetric soundings at 5-minute intervals while underway between stations on A1W and AR5.

### **2. Acoustic Doppler Current Profiler** (Murray Scotney)

The Hudson was equipped with a hull mounted RDI acoustic doppler current profiler. The transducer (serial number 177) had SC ADCP electronics (serial number 607) converted for shipboard use. Logging, using Transect software on a 386 PC, was started on June 8, 1995 at 1908Z along the Scotian Shelf. The configuration of the equipment results in a bin length of 8 meters and a total of 50 bins. The raw data are stored to disk and backed up every few days. The data are also averaged in real-time over 10-minute intervals. ADCP logging was stopped on July 3, 1995 on the Grand Banks.

### **3. Thermosalinograph** (Anthony W. Isenor)

An experimental along track measuring system developed by the Biological Sciences Branch at BIO was used for the first time on this cruise. The system consisted of a Seabird Model 25 CTD equipped with a Syphalitic Nepelometer (fluorometer) and a ship board mounted irradiance meter.

The Seabird was placed in a 200 litre container and seawater was pumped into the container from the ships seawater lines collected at a depth of about 5m below the surface. The container had a discharge line positioned such that the volume in the container was approximately 140 litres. The flow rate into the container was about 45 litres per minute.

A total of three computers are used to produce the final data file. One computer receives navigation data from the Bridge navigation computer. The navigation data is logged and then rebroadcast to a Seabird deck unit, where it is merged with the CTD signal. The merged signal is then sent to a second computer where a real-time display of position, time, temperature, salinity, chlorophyll and irradiance is shown. This computer rebroadcasts a 1-sec ascii representation of the merged signal to a third computer where the data are stored to hard disk.

### **4. XBT and XCTD**

No probes were used

### **5. Meteorological observations**

Routine reporting of meteorological variables was carried out by the ship's crew.

### **6. Atmospheric Chemistry**

There was no atmospheric chemistry programme.

### **7. Moving Vessel CTD** (Anthony W. Isenor)

The MVCTD (described in Clarke et al., 1995) is an instrument development project lead by Jean-Guy Dessureault. This device consists of a special winch, power block, launch and recovery chute, a heavy brass body containing a Falmouth Scientific Instruments CTD, Onset Tattle tail 8 computer and radio modem. The system is capable of obtaining profiles to greater than 1000 m while steaming at 10 knots. A profile is obtained by turning on the CTD by sending a signal to the fish via the radio modem. The operator then enters the target depth and the ship's speed into the PC computer that controls the winch and power block and initiates the profile. The entire operation of deploying and recovering the

fish is completely under computer control. The radio modem is then used to download the data from the fish when recovery is complete.

The MVCTD was used successfully on seven casts. At Station 1, The MVCTD was attached to the rosette frame carrying the Seabird CTD. This will allow a comparison of the MVCTD and Seabird CTD data sets.